

# RAW MATERIAL INVENTORY MANAGEMENT OF AN INTEGRATED IRON AND STEEL INDUSTRIES - A CASE STUDY

<sup>1</sup>ALOK KUMAR SINGH, <sup>2</sup>SANDEEP MONDAL

<sup>1,2</sup>Department of Management Studies, Indian School of Mines, Dhanbad  
E-mail: <sup>1</sup>alok.singh.bit@gmail.com, <sup>2</sup>sandeepmondal@hotmail.com

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**Abstract**— Supply Chain Inventory Management plays a very vital role in achieving operational excellence of any business organization. It is very critical and challenging task for an integrated iron and Steel plant to match the requirement of Raw Materials with fluctuating steel market demand. In this paper, we analyze the importance and criticality of Raw Materials Inventory Management with respect to various production rates in a typical integrated iron and steel plant of India. Furthermore, we analyze the various factors and functions, which affect the raw materials inventory management and perform the value analysis of the Inventory. We have analyzed the present system, based on the SWOT analysis and suggested the improvement by introducing proper cost effective material procurement and storage so as to minimize waste and material holdup and successfully meet the supply and demand of raw materials.

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**Index Terms**— Raw Material Inventory, Steel Industries, Cost Analysis.

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## I. INTRODUCTION

Every organization wishes to maximize its profit by maximizing its production and minimizing the cost of production. In Integrated iron and steel industries, cost of raw materials contributes around 70% to 80% of cost of production of Pig iron /Steel and the amount of money incurred on raw materials is higher than the cumulative amount for Men, Machine and other expenses. These industries have continuously running units like coke oven, Blast Furnace, Sinter Plant, SMS etc. Therefore, raw materials availability should not be interrupted at any cost because it not only adversely affects the production, but also malfunction the equipments like refractory of Blast Furnace, Coke Oven, SMS Converter.

Now a day all steel manufacturers face challenges in reducing production cost on the other hand cost of Raw materials raised 4- 5 times in last 5 yrs. Additionally, there is a continuous fluctuation in Steel market Demand, which increases the difficulty for the steel manufacturer to match the raw materials requirements in terms of right quantity, right time without compromising the quality at the cheapest price.

Therefore, Raw material Inventory management is the most feasible area that can offer opportunities for reduction of production cost and improvement of profits by matching Supply and demand by the feeding of raw materials into the production process with minimum chemical and physical variation and with minimum capital cost [1-3]. To achieve this, an organization must identify the fluctuation of demand and determine Inventory management system to respond such fluctuation of demand and improve co-ordination between supply chain activities.

The long term goal of the national steel policy is that India should have a modern and efficient steel industry of world standards, catering to diversify steel demand. The focus of policy would therefore be to achieve global competitiveness not only in term of

cost, quality and product mixes, but also in terms of global benchmarks of efficiency and productivity. This will require indigenous production of over 100 million tons per annum by 2019-2020. This implies a compounded annual growth of 7.3% per annum. To meet this goal iron and steel industries should have expanded and produce at maximum capacities. To achieve this each company has to give importance of raw material management system so that it can get good quality of raw materials at the lowest cost and with minimum blockage of working capital. So far the company under study has achieved 80% of its capacity in hot metal production. But to meet the demand, decrease the cost of production, companies should reach its maximum capacity for that company has to address the problem in their raw material inventory management system [4].

## OBJECTIVE OF THE STUDY

- i. Study the importance and criticality of Raw material inventory management and its control with respect to various production rates.
- ii. Study the various factors and functions which affect the raw material inventory management.

## II. STUDY OF RAW MATERIAL INVENTORY

### Demand of Pig Iron /Steel

Pig iron /Steel is a basic commodity for all industrial activities and quantum of its consumption is considered as an index of industrial prosperity. Bold steps of industrial reforms and liberalization were initiated in 1991, which has acted as stimulating factors for the industrial and economic activity. With continued growth in industrial and constructing activity, pig iron/Steel consumption is expected to record growth rates of 18-20%. It is one of the very few industries that have assumed a global character, with the development of one region affected the

industry all most everywhere. Pig iron was largely a localized industry till the mid of the 20<sup>th</sup> century. In 1950, for the instant a mere 11% of world production was travelling internationally. Currently international trade handles 40% of the global output, input. The growth has been most surprising the 2<sup>nd</sup> half of the 1990. Countries like China, South Korea, and Brazil invested heavily in steel.

The plummeting global steel demand had their impact on the Domestic market, which affected by the inflow of cheap imported product. Besides, the Indian Economy also has slowed down with negligible fresh investments in the infrastructure sector. They coincide with sizable new capacity added in early 1990's result a misjudge protection of domestic demand; this had lead to a vicious circle that affected the fortunes of the industry severely [5-15].

The production as well as the per capita consumption of pig iron is linked to the scale of economic development of any country. This was one of the fundamental factors for giving a big push to the industry in India soon after the independence. The pig iron sector was expected to lead the primary stage of economic growth. Pig iron was the primary source for laying the infrastructure and dragging the secondary and tertiary sector along the growth path. Approximate quantities of ore, fuel and flux required for producing one ton of Pig Iron and one ton of Sinter under Indian Condition are given in Table 1 and 2 respectively.

Table 1: Ore quantity for one ton Pig Iron

Materials	Quantity(In Ton)
Iron Ore/ Sinter	1.7 - 1.8
Coke	0.8 – 0.9
Lime Stone	0.4 - 0.5
Manganese Ore	About 50 kg
Quartzite	For adjustment

Table 2: Ore quantity for one ton Sinter

Materials	Quantity(In Kg)
Iron Ore Fines	850 - 950
Coke dust	70 - 80
Lime Stone	80 - 110
Dolomite	85 - 120
Sand	10 - 25

### Demand and Supply of various Raw materials for NINL

#### World scenario

The steel production and consumption in the last four to five years are mainly driven by its growth in China and the Asian countries. Spectacular economic growth has taken place in China since the beginning of 1990s. The apparent steel consumption of the finished steel, increased from 70 Mt in 1992 to 104 M in 1997 and 265 Mt in the year 2004. At present China is building its infrastructure in a big way. The requirement of Iron and steel is met from domestic production. As China has no better grade of major Raw material like

Iron Ore, it is one of the major importers of pig iron from India and NINL has share it. NINL has a positive edge as global transporter MMTC is taking care of marketing strategy [16].

#### Indian Scenario

The long-term goal of the national steel policy is that India should have a modern and efficient steel industry of world standards, catering to diversity steel demand. The focus of policy would therefore be to achieve global competitiveness not only in term of cost; quality and product mixes, but also in terms of global benchmarks of efficiency and productivity. This will require indigenous production of over 100 million tons per annum by 2019-20. This implies a compounded annual growth of 7.3% per annum. To meet this goal, iron & steel industry in India should expand and produce at maximum capacities. So far NINL achieved 80% of its capacity in hot metal production. To meet the demand, decrease the cost of production NINL should reach its maximum capacity.

### NINL's requirement of raw material w.r.t production capacity

#### Iron Making at NINL Plant

Blast Furnace is the classical and by far the most economical route for Pig Iron production. One Blast Furnace of 1,915 m<sup>3</sup> useful volumes has been installed to produce about 1,100,000 t/yr of gross hot metal.

#### Steel Making at NINL

The Basic Oxygen Furnace (yet to be installed under project stage Phase – II) is the classical and by far the most economical route to steel making from BF hot metal. Two numbers of 80 t. Basic Oxygen Furnaces are selected to produce 614,000t/yr. of billets. Out of this 313,000 t/yr. will be rolled into wire rods balance 27,600 t/yr. will be sold as billets in the market.

Rolling Mills at NINL

### Annual Requirements of Raw Materials for typical Iron and Steel Industries under study

In order to support hot metal production of 1.1 million tons at 100% capacity utilization, the required quantities of critical inputs such as Iron Ore Lumps (CLO) , Iron Ore fines, Coal, Limestone, Dolomite etc based on assumption of different ratios of iron ore (CLO) to sinter is given in Table 3.

Table 3: Quantity of Ore

Materials	Size	Quantity(In Tons)
Iron Ore		
• BF Grade	10-30	405000
• SP Grade Fines	-10	1367000
• SMS Grade Lump	10 - 40	10600
Lime Stone		
• BF/SP Grade	5 – 75	145000
• SMS Grade	30 – 60	117500
Dolomite		
• BF/SP Grade	5 – 75	108000
Manganese Ore	10-30	40000
Quartzite	10-50	45000

### III. METHODOLOGY

Here, we present a Supply chain management procedure of Raw materials at the company under study. The agencies involved in the company are presented in Table 4.

Table 4: Agency involved

Agency	Abbreviation
Production Planning and Control Department	PPC
Raw Material Department	RMD
Commercial/ Stores	COML./GPS
Traffic	TRF
Railway	RLY
Sinter Plant	SP
Blast Furnace	BF
Supplier/Representative of Supplier/Truck	SUP
Security	SEC
Operator of in Motion Weighbridge	OWB
Quality Control Laboratory	QCL
Raw Material Handling System	RMHS
Finance and Accounts Department	F&A
MMTC	MMTC

Following are the steps involved in supply chain management of raw material system:

- Step 1: Production Planning & Control department prepare yearly projections of the requirement of the Raw Materials based of production demand and send to Raw material department.
- Step 2: Based on the projections of Production Planning & Control department and annual stock balances, Raw Materials department projects the yearly & monthly requirements along with the specifications in consultation with the consuming departments(Sinter Plant / Blast Furnace / RMHS) and the same is forwarded to commercial department for initiating procurement action.
- Step 3: Commercial department calls for tenders or advise MMTC to go for tenders. After receiving the quotations, MMTC Commercial department sends these quotations, to Raw Materials department for evaluation.
- Step 4: Raw Materials department sends back the quotations along with the evaluations to the commercial department after consulting the user department, viz., Sinter Plant / Blast Furnace is required.
- Step 5: Commercial department put up the quotations along with the evaluations to Competent Authority for approval.
- Step 6: After the approval Commercial department / MMTC issues Agreement to the supplier and send the copies of agreement to RMD, finance and QCL.
- Step 7: The consuming department (Sinter Plant / Blast Furnace / RMHS) gives monthly tock balance to PPC, RMD and Finance.
- Step 8: Based on the stock balances and the changes, if any, in the production plan, the PPC informs the modification in the monthly requirement, if any, to RMD and RMD accordingly informs the commercial department/ MMTC the modification in the delivery schedule, if required.
- Step 9: If the requirement on the material in particular month is less than that of the schedule given in the agreement, the Commercial department/ MMTC issues an amendment in the delivery schedule to the supplier with a copy to the Raw material and Finance Department.
- Step 10: The Supplier/Buyer/ MMTC appoints the public analyst, if required as per the agreement from the panel of approved public Analyst of NINL.
- Step 11: Supplier facilitates the pre-dispatch sampling of analysis work by the approved public Analyst appointed at the sources as per the terms of the Agreement /Contract.
- Step 12: Supplier loads the material in the presence of NINL/MMTC respective and arranges to send the rail receipts(RRs) and other relevant documents like Weighment Statement (Weighment done in weighbridge/Public Analyst's Assessment on volumetric Basis), Analysis report in duplicate etc. through representative.
- Step 13: Information regarding the rakes dispatched, expected time of arrival collected by traffic and on word communications is made available to PPC, RMD, RMHS for subsequent course of actions.
- Step 14: When Rake reaches at NINL gate, the operator of in motion weighbridge arranges for collection of all the papers related to commodity carrying the rake from the railway staff with the rake and weighment of the whole rake by ensuring accurate speed of train. In case of any error cropped up during weighment or weighment of the full rake could not be taken for any reason whatsoever, reweighment must be taken and no Rake shall be passed on without weighment.
- Step 15: After weighment of the rake Traffic department organizes in coordination with Railway carriage staff for placement of the rake for tippler.
- Step 17: Before handing over the rake to RMHS for tipping, representative of RM/TRF department ensures the missing wagons, material other than specified statement etc. if any and inform railway authorities, Sukhinda Station. All the formalities are made in the presence of C.G.S., Railways for missing wagons or any other abnormalities.
- Step 18: While handling over the rake to shift in charge RMHS, the Traffic department gives in

writing signifying all details of the rake Commodity loaded. Total No. of wagons, Missing wagons, empty wagons & sick wagons (if any), Total No. of loaded wagons (commodity wise in case of mixed rakes) timing for placement and drawn out etc.

**SWOT (strengths, weaknesses, opportunities, and threats) Analysis of Company**

It is a structured planning process that evaluates the four elements of a project or company. A SWOT analysis can be carried out for a company, product, place, industry, or person. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective. Here, we present all the four elements of the company as follows:

**Strength:** Characteristics of the business or project that give it an advantage over others

- Captive Sinter Plant, Power Plant, Coke Oven Battery.
- Reasonably modern technology.
- Strategic location with proximity to Paradeep port.
- Located mid east high consuming eastern market for pig iron/ Steel.
- Low manpower and the average age of employee stands below 35.
- MMTC’s strength in marketing and in international trade

**Weakness:** Characteristics that place the business or project at a disadvantage relative to others

- Production shops with single units, which are heavily dependent on each other.
- No captive sources of Raw Materials except Iron ore which is yet not operational.
- Time over run in commission of present facility.
- Comparative high debt cost vis-à-vis competition.

**Opportunities:** Elements that the business or project could exploit to its advantage

- Modern commissioned integrated iron making facilities, a major attraction to strategic investor.
- Surplus coke making facility, advantage in current high coke price.
- Easy access to export market.
- Scope of enhancement of productivity of present units by incorporating process/technology changes.
- Captive mining of iron ore to reduce production cost. The mines are just located 100 km away.

**Threats:** Elements in the environment that could cause trouble for the business or project

- Increase in competition from upcoming projects in the area.
- Global shortage of Raw Materials.
- Global Volatility of Steel Demand.
- Spiraling input cost.

**IV. COST ANALYSIS**

In this analysis we present the factors of the cost of the production [16-17]. Fig. 1, presents the %age of different factors to the unit cost of the product. From this figure we can see that the major factor is the raw material of the product in production. Figs. 2&3, present the %age of all type of the raw materials required in the integrated Iron and steel company.

Fig 1: Expenditure Breakup

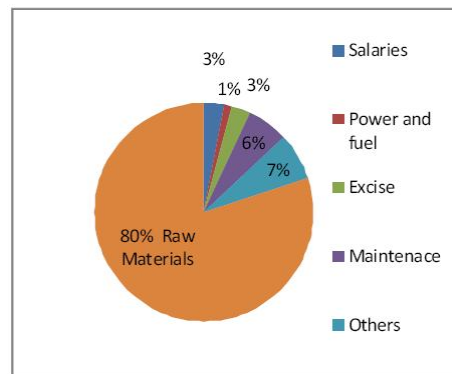


Fig 1: Expenditure Breakup

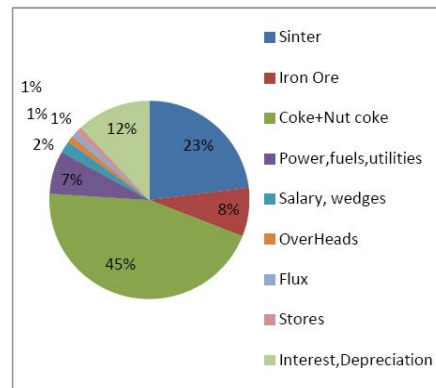


Fig 2: Break up Hot Metal Works Cost

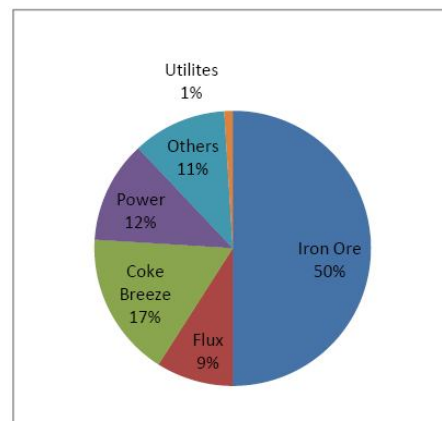


Fig. 3: Breakup of Sinter Works Cost

From the above cost analysis, it is clear that major Raw materials for typical Integrated Steel Plants in terms of quantity and cost percentage of working capital is Iron Ore and Coal. Hence company should make stiff policy for raw material inventory management for these Raw Materials.

**Receipt and Consumption pattern of Iron Ore**

The receipt and consumption of major Raw materials (Iron ore) by NINL for the last two years (2014-2016) is given in Figures 4&5.

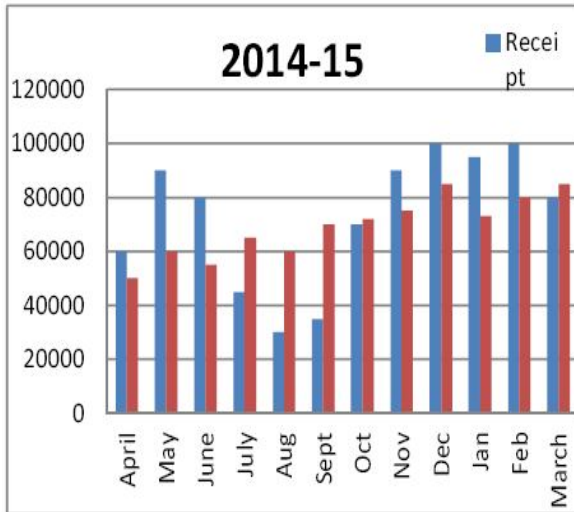


Fig. 4: receipt of Iron ore in 2014-2015

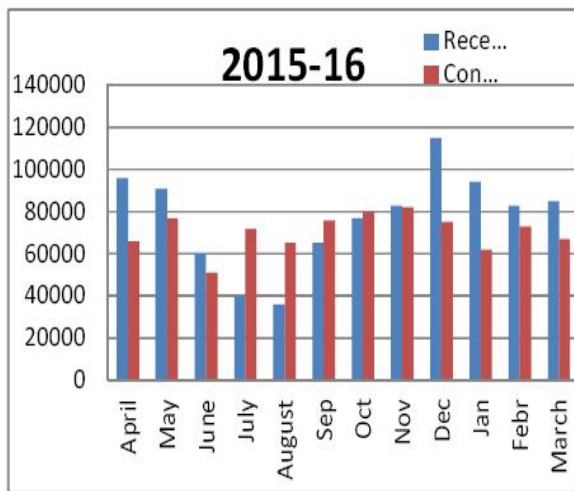


Fig. 5: receipt of Iron ore in 2015-2016

**V. VALUE ANALYSIS**

In Fig. 6, we present the analysis of the inventory to working capital ratio of different company in Steel Sector [18-21]. From this figure we have found that the companies in Steel Sector revealed that the average inventory to working capital ratio is 0.48. Moreover, from this table it is evident that SAIL was carrying inventory equal to 0.58 times and NINL was carrying inventory 1.21 times of their working capital, which was on the higher side in comparison with the average ratio of 0.48 times.

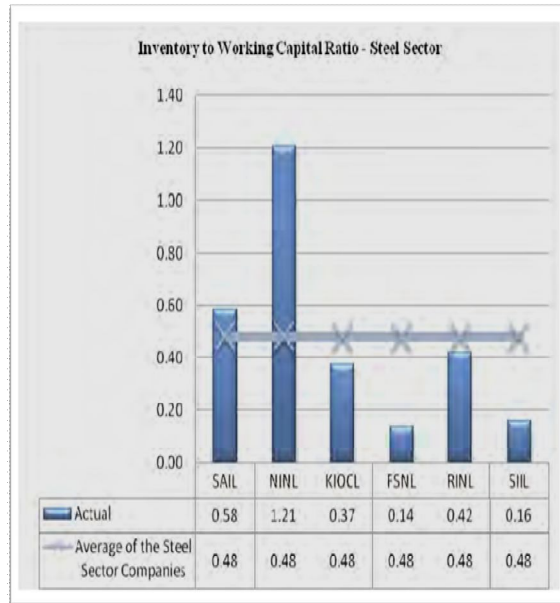


Fig 6: Inventory to working capital ratio-steel sector

**Major Cause of High Inventory to Working Capital Ratio**

After investigating the system, we have found the various major cause of high inventory to working capital ratio which are briefly discussed as follows:

- **Non Operational of Captive Iron Ore Mines**

In the present scenario, all the leading Integrated Steel Plants have their own captive mines for Iron Ore/Limestone/Dolomite/Quartzite/Manganese etc. Besides, except TATA Steel, no steel plants has any captive source for coking coal reserve in India hence under Coal India Ltd is not sufficient enough to cater to the demand supply of Indian Steel plant as a result almost all the steel plants have made long term agreements with foreign companies mostly in Australia & New Zealand for procurement of low ash metallurgical coal and with China & other countries for Lam coke.

In NINL, pending execution of mining lease for Iron Ore Mines in district of Sundergarh, Keonjhar in Orissa, Iron Ore is procured from mines within and other state. The captive mine is yet to be executed due to the clearances from Ministry of Environment, Forest and other Govt. statutory authorities. Hence company procure its Iron Ore requirement from other sources which is non sustainable and non reliable. Company has not enter into long term agreement with any mining companies till date. Hence apart from its Inventory control mechanism, company has to procure its Iron Ore requirement based on the availability of iron ore at the time of procurement.

- **Non Utilization of Indian Coal:-**

Company utilize 100 percent imported coal for coke production where as other Steel Plant in the country utilize both imported as well as indigenous coking coal with due proportions. Indigenous Coking Coal is

high ash content compared to imported coal. But Imported coking coal is costlier compared to indigenous coking coal, iron and Steel Industries have been preferred to utilize the blend concept of imported coal and indigenous coking coal. This has proved lower cost economics in manufacturing the finished products. Company has not adopted this concept. Some of the Draw Backs in Utilizing only imported coking coal could be-

1. Cost economics in higher side.
2. Long term agreement with foreign companies is difficult.
3. Long Lead Time Cause high Inventory.
4. Any problem in overseas will adversely affect the Inventory.

- **Inventory control Method.**

Current Inventory control mechanism is based on periodic review system in which level of inventory is reviewed at the end of each month and based on that and any changes in production schedule, requirement of raw materials is projected and change the delivery schedule is made to meet the requirement.

EOQ  $\{\sqrt{2DS/H}\}$  is a mathematical formula designed to minimize the combination of annual holding cost and ordering costs. But in case of raw material management in Steel company, the annual holding cost is in lakhs where-as ordering cost is nominal (thousand per order) therefore total Inventory cost is due to annual carrying cost only. Hence it is inevitable for the steel plant to purchase the raw materials at regular interval as per the requirement by using just in time technique.

But by analyzing the receipt and consumption pattern of last two yrs. it is clear that there is a big mismatch between iron ore receipt and consumption fig. for each month, From October to May, The company is purchase more than the requirement and in the month of June to September receipt is less than consumption. The major reason of this mismatch from June to September is due to facing difficulties in handling of Iron Ore during monsoon season. Which cause in increase in demurrage cost per rake. Hence cost of Iron ore per ton increase

Total Cost of Iron Ore/ ton = Unit Cost of Iron Ore / ton+ Railway Freight/ton + Demurrage\*cost.

\*Demurrage is the penalty given to railway for detention of railway rake beyond 8 hrs. for unloading of iron ore.

Avg. Demurrage per rake is increase around 80% in monsoon season. But on the other hand railway freight decreased by 17%. Railway Freight is mainly depend upon distance between source and the plant. Further the contribution of unit cost of iron ore is around 80% to the total cost of iron ore and railway freight contribution is around 15% -20% of total cost. On the other hand demurrage cost contribution is around 1% to the total cost. Hence apart from the

increasing demurrage cost if company will receipt iron ore in monsoon season as per their requirement, company will benefited because of cost discount. Therefore requirement of storage of raw material on other season is decreased and company will decrease Inventory to working capital ratio. Most beneficial condition for the company is that its receipt and consumption figure for each month will as close as possible. By satisfying these condition company will have to maintain minimum inventory to working capital ratio.

- **Absence of any Enterprises Resources planning Software.**

Presently, company does not have any ERP software. Presently, all the activities required for supply chain management takes more time with less accuracy and with high cost. Company has to adopt any ERP software for its supply chain Management and trained their employee on that so that all the activities should take less time and also response to any changes very effectively.

## CONCLUSION

Optimum inventory is the goal of every organization. Over inventory and under inventory, both cause financial impact and health of the business as well as effect business opportunities. The demand and supply of Raw Material are very uncertain in steel industries, hence raw material inventory system should be designed over a range of probable values. Raw material Inventory Management should be an integrated system and dependence of function models for decision making, so that response to a problem is quick and appropriate. When this happens organization achieved optimum inventory level, reduce stock outs, Lower unit cost of materials, etc. The mismatch between demand and supply of raw material to different Indian Iron & Steel Industries leads to price volatility. This adversely affects the iron manufacturing industries for integrated raw material inventory control. Consistent raw material feed owing a captive source can be proved more beneficial. Contrary to above purchasing from non captive sources economically if viable, can be adopted, but cannot be trusted upon unforeseen hindrance and force measures.

At the threshold of steel boom in domestic market and international market, procuring raw materials from valued sources with cost competitiveness, the company has to go a long way for its Inventory Control Management for Iron Ore Fines and Blending of Indian Coal with Imported coal is to be practiced for not only cost control but also abundant availability. Constraints in the procurement and handling are to be overcome as mentioned and Inventory cost can be decreased by adopting a selective inventory control mechanism.

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